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MAY 1 8 2004
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Patent

Attorney Docket No. 024445-426

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of

Marcus Rodmar et al.

Application No.: 10/760,387

Filing Date: January 21, 2004

Title: COATED CEMENTED CARBIDE INSERT

Group Art Unit: 1774

Examiner: Unassigned

Confirmation No.: 1324

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Country: Sweden

Patent Application No(s).: 0300175-7

Filed: January 24, 2003

In support of this claim, enclosed is a certified copy(ies) of said foreign application(s). Said prior foreign application(s) is referred to in the oath or declaration. Acknowledgment of receipt of the certified copy(ies) is requested.

Respectfully submitted,

BURNS, DOANE, SWECKER & MATHIS, L.L.P.

P.O. Box 1404
Alexandria, Virginia 22313-1404
(703) 836-6620

Date: May 18, 2004

By Ronald L. Grudziecki

Ronald L. Grudziecki
Registration No. 24,970

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PATENT- OCH REGISTRERINGSVERKET

(71) Sökande Sandvik AB, Sandviken SE
Applicant (s)

(21) Patentansökningsnummer 0300175-7
Patent application number

(86) Ingivningsdatum 2003-01-24
Date of filing

Stockholm, 2003-12-30

För Patent- och registreringsverket
For the Patent- and Registration Office

Juris Rozitis

Avgift
Fee 170:-

Coated cemented carbide insert

The present invention relates to a coated cemented carbide cutting tool insert for the machining in general steel applications with large requirements on wear resistance and toughness behaviour of the cutting edge. The tool is particularly suitable for turning of stainless steels.

When cemented carbide cutting tools are used in the machining of steels, the tool is worn by different mechanisms such as abrasive and chemical wear, chipping and fracturing of the cutting edge. The cutting of stainless steel is considered to be a particularly difficult machining operation since in addition to the above mentioned wear mechanisms also adhesive wear is prominent. Adhesive wear is obtained when smearing materials like stainless steels during the cutting operation continuously adhere to and tear off material from the cutting edge. A short tool life is therefore very frequent when machining stainless steels. Furthermore, when cutting stainless steels at high cutting speeds, the thermal energy transferred to the cutting edge is considerable and the tool edge may partly or entirely deform plastically. This mode of deterioration of the cutting edge is known as plastic deformation wear. A large requirement of plastic deformation resistance is in clear contrast to a large requirement of edge toughness.

Multilayer coatings comprising first and second coating layers of different materials which are alternately laminated on the substrate, each of the first coating layers having a first thickness and each of the second coating layers having a second thickness are known. The two layers should preferably have a different crystal structure and/or at least different lattice spacings. One example of such a technique is when the Al_2O_3 growth periodically is interrupted by a short TiN deposition process resulting in a $(Al_2O_3+TiN)_x$ multilayer structure see e.g. Proceedings of the 12:th European CVD Conference page pr.8-349. GB 2048960A discloses a multilayer coating with a multiplicity of alternating layers of 0.02 to 0.1 µm consisting of hard material of different compositions. US 4,599,281 discloses a multilayer coating with alternating layers of an aluminium-boron mixed oxide and another oxide layer of e g Ti(C,N,O). Dreyer and Kolaska, Metals Society (Book 278), London, England (1982) 112-117 report

an Al-O-N multilayer. In US 4,984,940 Bryant et al. disclose a cutting insert composed of a cemented carbide substrate with 6.1-6.5 wt% cobalt, a coating including a base layer of titaniumcarbonitride followed by a multilayered coating consisting of a plurality of alumina layers. A cemented carbide substrate with a coating comprising 6-8 alumina layers is also claimed in US 5,700,569. WO 99/58738 describes a tool consisting of a hard wear resistant substrate and a CVD multilayer of about 50 layers. EP-A-1103635 claims a cutting tool consisting of a cemented carbide substrate with 9.0-10.9 wt% cobalt and a coating comprising a medium temperature CVD (MTCVD) deposited TiCN-layer and a multilayer composed of totally 7-41 layers of α-alumina and TiN or Ti(C,N). EP-A-1245698, EP-A-1245700, and EP-1209255 also relate to multilayer coatings.

Smoothing of coatings by mechanical post treatment in order to e g minimize the friction between the tool and the workpiece is disclosed in EP-A-127416, EP-A-298729, EP-A-693574 and EP-A-683244.

It is an object of the present invention to provide a cutting tool insert able to simultaneously withstand all the above mentioned wear modes.

It is a further object of the present invention to eliminate the deficiencies of prior art tool products and to provide a high performance cutting tool.

It is a still further object of the present invention to provide a tool with excellent cutting performance in demanding stainless steel turning operations.

It has surprisingly been found that a cemented carbide cutting insert with a coating including a mechanically post-treated multilayer consisting of a plurality of alternating Al_2O_3 and $TiC_xN_yO_z$-layers meets these requirements. The insert exhibits excellent toughness behaviour especially during intermittent cutting and also a good resistance to adhesive wear and to plastic deformation.

Fig 1. is a scanning electron micrograph (SEM) of a cross-section of the coating according to the present invention in which:

A. TiN,

B. columnar Ti(C,N),

C. TiN,

D. multilayer $(Al_2O_3+TiN)_6Al_2O_3$ and

E. TiN+TiC+TiN.

Fig 2.1 is a schematic of the cross-section of the edge without a post-treatment.

Fig 2.2 is a schematic of the cross-section of the edge with a post-treatment according to the invention where the outermost coating E is removed.

Fig 2.3 is a schematic of the cross-section of the edge with a post-treatment according to the invention where the outermost coating E and the multilayer $(Al_2O_3+TiN)_xAl_2O_3$ are removed.

Fig 3 is the schematic of the cross-section of the edge with a post-treatment according to prior art.

Fig 4 is a SEM picture of the edge post-treated according to the invention.

Fig 5 is a SEM picture of the post-treated edge of reference with thicker individual alumina layers (Insert D).

Table 1 summarises the results of examples A-G.

More specifically, the invention relates to a WC+Co-based cemented carbide substrate with additions of cubic carbides, a specific grainsize range of the WC grains, a specific composition range of WC+Co and a coating on the cemented carbide substrate including an innermost thin layer of equiaxed $TiC_xN_yO_z$ followed by a layer of columnar $TiC_xN_yO_z$, a thin layer of equiaxed $TiC_xN_yO_z$, a multilayer with a periodic variation of $TiC_xN_yO_z$ and Al_2O_3 layers ($x+y+z\leq1$) and an outermost layer of TiC_xN_y ($x+y\leq1$). At least the non-oxide outermost layer in areas in direct contact with material from the work-piece around the cutting edge is missing.

The composition of the cemented carbide substrate should be 7-10.5 wt% Co, preferably 8.0-9.5 wt% Co, and 0.2-1.6 wt% cubic carbides, preferably 0.4-1.0 wt% cubic carbides of the metals Ta, Nb and Ti and possibly other carbides of the elements from group IVb, Vb or VIb of the periodic table and balance tungsten carbide (WC). The preferred average grain size of the WC is 1.5-3.5 µm, preferably 1.9-2.1 µm.

In an alternative embodiment the cemented carbide substrate has cubic carbide depleted and binder enriched volume near the surface. The measured distance from the surface should be 5-50 µm until the end of the cubic carbide depletion. In this embodiment the composition comprises 7.0-10.5 wt% Co and 4.0-9.0 wt% cubic carbides and balance tungsten carbide (WC). Said cubic carbides

may contain substantial amounts of N and O such that certain microstructural constituents should be referred to as e.g. carbonitride or oxycarbonitride. The cubic carbides are preferably Nb, Ta and Ti but may include carbides of elements from group IVb, Vb or VIb of the periodic table. The amount of N should be in the range of 0.01-0.2 wt%.

The hard and wear resistant refractory coating (Fig 1) deposited on the cemented carbide substrate according to the present invention comprises:

- a first, innermost layer (A) of $TiC_xN_yO_z$ with $x+y+z\leq1$, preferably $y>x$ and $z<0.2$, most preferably $y>0.8$ and $z=0$, with equiaxed grains with size <0.5 µm and a total thickness <1.5 µm but >0.1 µm preferably 0.1-0.6 µm.

- a second layer (B) of $TiC_xN_yO_z$ with $x+y+z\leq1$, preferably with $z=0$, $x>0.3$ and $y>0.3$, most preferably $x>0.5$, with a thickness of 0.4-3.9 µm, preferably 1.5-3.0 µm with columnar grains.

- a third layer (C) of $TiC_xN_yO_z$ with $x+y+z\leq1$, preferably $y>x$ and $z<0.2$, most preferably $y>0.8$ and $z=0$, with equiaxed grains with size <0.5 µm and a total thickness <1.5 µm but >0.1 µm, preferably 0.2-0.8 µm in a first embodiment. This layer (C) is in a second embodiment omitted.

- the total thickness of the layers A+B+C is 0.7-4.5 µm, preferably 1.2-4.0 µm. Preferably, the layers A and C are each thinner than the layer B.

- a multilayer (D) consisting of a plurality of alternating Al_2O_3 and $TiC_xN_yO_z$ ($x+y+z\leq1$) layers, preferably κ-Al_2O_3 and TiN layers. The innermost and the outermost layer of the multilayer sequence are Al_2O_3-layers. The total number of layers, including both the $TiC_xN_yO_z$- and Al_2O_3-layers, is between 5 and 31, preferably 11 and 15 layers. The Al_2O_3-layers have an individual layer thickness of <0.5 µm, preferably 0.2-0.5 µm. The $TiC_xN_yO_z$-layers have an individual layer thickness of 0.01-0.2 µm, preferably 0.02-0.15 µm. The total thickness of the multilayer is 1.0-4.0 µm, preferably 1.5-3.5 µm. The grain size of the Al_2O_3-layer is equal to or less than the thickness of the Al_2O_3-layer.

- an outermost layer system (E) consisting of one or several layers in sequence of TiC_xN_y ($x+y\leq1$) or combinations thereof, preferably three layers in sequence of TiN, TiC, and TiN. The total thickness is <2.0 µm but >0.1 µm, preferably 0.2-1.0 µm.

- the total thickness of the layers A-E is 2.0-8.0 µm, preferably 4.0-7.0 µm.

The outermost part of the coating is missing around the edge such that area corresponds to the chip contact on the rake side and the contact with the work piece on the flank side. Most preferably correspond to the primary land on the rake side when a primary land exists on the geometry at hand such that the coating is missing a distance from a point defined in fig. 2.2 with a perspective perpendicular to the insert face planes on the rake face "a" and on the flank face "b". These distances depend on different insert geometries and insert sizes etc on the rake side preferably corresponding to $0.03<a<0.9$ mm and $0.02<b<0.2$ mm independent of the existence of a primary land or not, $a>b$, preferably $a>1.5b$. In one embodiment only the layer E is missing. In another embodiment both layers D and E are missing in parts of the area.

The removal of the outermost layer (E) at the edge-line will expose the Al_2O_3 layers along the edge line. The edge-line is defined as the edge-honed portion of the cutting tool insert. The untreated edge-line is illustrated in Fig. 2.1 and the post-treated edge-line is illustrated in Fig. 2.2 and 2.3. It is preferable that only the non-oxide top-layer and parts of the multilayer are removed. The $TiC_xN_yO_z$ layers (A+B+C) may, however, be visible on minor parts of the edge line (Fig 2.3).

The present invention also relates to a method of making the above mentioned coated cutting tool insert comprising preferably a WC-Co based cemented carbide body including an amount lower than 1.6 wt% of cubic carbides and with a composition of WC+Co in the range of 7-10.5 wt% Co, preferably 8.0-9.5 wt% Co, and an amount of cubic carbides in the range of 0.2-1.6 wt%, and the balance is made up by WC. The average WC grainsize is found in the range of 1.5-3.5 µm. The cemented carbide body is mainly produced by mixing of powders, ball milling, spray-drying, some pressing method followed by sintering according to conventional methods and pre-treatment before coating.

In an alternative embodiment the cemented carbide substrate is made in such a way that a cubic carbide depleted and binder phase enriched volume near the surface is obtained by sintring in vacuum after the addition of a low amount of nitrogen. The measured distance from the surface should be 5-50 µm until the end of the

cubic carbide depletion. In this embodiment the composition comprises 7.0-10.5 wt% Co and 4.0-9.0 wt% cubic carbides and balance tungsten carbide (WC). Said cubic carbides may contain substantial amounts of N and O such that certain microstructural constituents should be referred to as e.g. carbonitride or oxycarbonitride. The cubic carbides are preferably Nb, Ta and Ti but may include carbides of elements from group IVb, Vb or VIb of the periodic table. The amount of N in the substrate should be in the range of 0.01-0.2 wt%.

The body is then coated with

- a first (innermost) layer(A) of $TiC_xN_yO_z$ with $x+y+z\leq1$, preferably $y>x$ and $z<0..2$, most preferably $y>0.8$ and $z=0$, with equiaxed grains with size <0.5 µm and a total thickness <1.5 µm but >0.1 µm using known chemical vapour deposition, CVD, methods.

- a layer of $TiC_xN_yO_z$(B) with $x+y+z\leq1$, preferably with $z=0$, $x>0.3$ and $y>0.3$ with a thickness of 0.4-3.9 µm, preferably 1.5-3.0 µm with columnar grains, using preferably a moderate temperature CVD, MTCVD, technique (using acetonitrile as the carbon and nitrogen source for forming the layer in the temperature range of 700-900 °C). The exact conditions depend to a certain extent on the design of the equipment used.

- a layer of $TiC_xN_yO_z$(C) with $x+y+z\leq1$, preferably $y>x$ and $z<0.2$, most preferably $y>0.8$ and $z=0$, with equiaxed grains with size <0.5 µm and a total thickness <1.5 µm but >0.1 µm using known CVD-methods. This layer (C) is as a second embodiment omitted.

- The total thickness of the layers A+B+C is 0.7-4.5 µm, preferably 1.2-4.0 µm. Preferably, the layers A and C are each thinner than layer B.

- a multilayer(D) consisting of a plurality of alternating Al_2O_3 and $TiC_xN_yO_z$ ($x+y+z\leq1$) layers, preferably κ-Al_2O_3- and TiN-layers, using known CVD-methods. The innermost and the outermost layer of the multilayer sequence are Al_2O_3-layers. The total number of layers, including both the $TiC_xN_yO_z$- and Al_2O_3-layers, is between 5 and 31, preferably 11 and 15 layers. The Al_2O_3-layers have an individual layer thickness of <0.5 µm, preferably 0.2-0.5 µm. The $TiC_xN_yO_z$-layers have an individual layer thickness of 0.01-0.2 µm, preferably 0.02-0.15 µm. The total thickness of the multilayer is 1.0-4.0 µm, preferably 1.5-3.5 µm. The grain size of the Al_2O_3-layer is equal to or less than the thickness of the Al_2O_3-layer.

- preferably, an outermost layer system(E) consisting of one or several layers in sequence of TiC_xN_y ($x+y\leq1$) or combinations thereof using known CVD-methods. The total thickness is <1.5 □m.

G. the total thickness of layers A-E is 2.0-8.0 □m.

The coating is mechanically post-treated to expose the multilayer along the edge line by a brushing, blasting, grinding operation or combinations thereof such that the areas on the rake and flank face with chip and work piece contact respectively have been treated.

In the preferred method two nylon brushes containing SiC grains with settings and insert positioning such that one brush mainly brushes the rake side and the other mainly the flank side to achieve the desired properties on the flank and rake face of the insert.

<u>Examples</u>

The following inserts and examples are selected to exemplify the advantages with the invention. These examples are summarised in table 1.

The presented inserts have been tested with identical conditions in each example.

<u>Insert A</u>. Cemented carbide turning inserts according to the invention with the composition 8.75 wt% Co, 1.17 wt% Ta, 0.29 wt% Nb and balance made up by WC and with an average WC grain size of 2.0 µm were coated with 0.5 □m TiN (innermost layer), 2.2 □m columnar Ti(C,N), and 0.5 □m equiaxed TiN, 2.2 □m (□-Al_2O_3+TiN)$_6$□-Al_2O_3 multilayer with 250 nm thick □-Al_2O_3-layers and 80 nm thick TiN-layers and an outermost layer of 0.5 □m TiN+TiC+TiN. The coating was post-treated along the edge line with nylon brushes containing SiC grains. The outermost coating was removed a=0.1 mm and b=0.05 mm into the rake and flank face.

<u>Insert B</u>. Commercial cemented carbide turning inserts having 10.5 wt% Co, 1.16 wt% Ta, 0.28 wt% Nb and balance made up by WC and with an average grain size of 1.7 □m, was coated with an innermost 0.5 □m equiaxed TiN layer, 4.0 □m columnar Ti(C,N), 1.0 □m □-Al_2O_3, and an outermost layer of 0.5 □m TiN+TiC+TiN. The coating was brushed along the edge line with nylon straw brushes

containing SiC grains. The outermost coating was removed a=0.025 mm and b=0.05 mm along the edge line according to prior art.

<u>Insert C.</u> Cemented carbide turning inserts with the composition 9.15 wt% Co, 1.17 wt% Ta, 0.29 wt% Nb and balance made up by WC and with an average WC grainsize of 1.7 µm, were coated with 0.5 µm TiN (innermost layer), 2.2 µm columnar TiCN, a 1.8 µm $(\kappa\text{-}Al_2O_3+TiN)_5\kappa\text{-}Al_2O_3$ multilayer, and an outermost layer of 0.5 µm TiN. The coating was post-treated along the edge line with nylon brushes containing SiC grains. The outermost coating was removed a=0.025 mm and b=0.05 mm along the edge line, according to prior art.

<u>Insert D.</u> Identical substrates to C were coated with 0.5 µm TiN (innermost layer), 2.3 µm columnar Ti(C,N), a 1.9 µm $(\kappa\text{-}Al_2O_3+TiN)_3\kappa$-Al2O3 multilayer, and an outermost layer of 0.5 µm TiN. The coating was post-treated along the edge line with nylon brushes containing SiC grains. The outermost coating was removed a=0.025 mm and b=0.05 mm along the edge line according to prior art.

<u>Insert E.</u> Identical substrates to C were coated with an innermost 0.5 µm equiaxed TiN layer, 2.2 µm columnar Ti(C,N), 1.5 µm $\kappa\text{-}Al_2O_3$, and an outermost layer of 0.5 µm TiN+TiC+TiN. The outermost coating was removed a=0.025 mm and b=0.05 mm along the edge line according to prior art.

<u>Insert F.</u> Cemented carbide turning inserts having 7.5 wt% Co, 2.72 wt% Ta, 0.44 wt% Nb, 1.83 wt% Ti, 0.09 wt% N and balance made up by WC and with an average grain size of 2.0 µm and with a binder phase enriched and cubic carbide free zone 26 µm from the surface were coated with 0.5 µm TiN (innermost layer), 2.2 µm columnar Ti(C,N), and 0.5 µm equiaxed TiN, 2.2 µm $(\kappa\text{-}Al_2O_3+TiN)_6\kappa\text{-}Al_2O_3$ multilayer and an outermost layer of 0.5 µm TiN+TiC+TiN. The coating was post-treated along the edge line with nylon brushes containing SiC grains. The outermost coating was removed a=0.1 mm and b=0.05 mm into the rake and flank face.

<u>Insert G.</u> Commercial cemented carbide turning inserts having 7.5 wt% Co, 2.72 wt% Ta, 0.44 wt% Nb, 1.83 wt% Ti, 0.09 wt% N and

balance made up by WC and with an average grain size of 2.0 µm and with a binder phase enriched and cubic carbide free zone 26 µm from the surface were coated with an innermost 0.5 µm equiaxed TiN layer, 7.5 µm columnar Ti(C,N), 1.2 µm κ-Al_2O_3, and an outermost layer of 0.5 µm TiN+TiC+TiN.

The coating was brushed along the edge line with nylon straw brushes containing SiC grains. The outermost coating was removed a=0.025 mm and b=0.05 mm along the edge line as disclosed in EP-A-693574.

Example 1

Inserts from A and B were tested in a turning operation.

Operation:	Axial and facial turning in a bar
Work piece material:	Austenitic stainless steel AISI 316L
Cutting Speed:	225 m/min
Feed rate:	0.3 mm/rev
Depth of cut:	2.0 mm
Insert style:	CNMG120408-MM

Results:	Tool life (min)
Insert A: (invention)	ca 10
Insert B: (prior art)	ca 6

Comment: Tool life criterion was maximum flank wear 0.3 mm of the cutting edge line. The wear develops irregularly due to local plastic deformation. This example shows the improvement in plastic deformation resistance.

Example 2

Inserts from A and B were tested in a turning operation.

Operation:	Intermittent cutting of an assembly part
Work piece material:	Austenitic stainless steel, AISI316L
Cutting speed:	160 m/min
Feed rate:	0.2-0.3 mm/rev
Depth of cut:	0.5-1.5 mm

Insert style:	SNMG120412-MR

Results:	Tool life (min)
Insert A: (invention)	8.2
Insert B: (prior art)	4.2

Comment: The wear in this test was flank wear, thermal cracks, chipping. The tool-life-determining criterion is chipping i.e. edge toughness. Followingly it shows improved edge toughness in combination with maintained properties in other wear modes.

Example 3

Inserts from A and B were tested in a turning operation.

Operation:	Continuous cutting in a cast ring
Work piece material:	Austenitic stainless steel, AISI316L
Cutting speed:	110 m/min
Feed rate:	0.3 mm/rev
Depth of cut:	3.5 mm
Insert style:	CNMG120412-MR

Results:	Tool life (min)
Insert A: (invention)	18.6
Insert B: (prior art)	12.4

Comment: The criterion in this test is working through a full item taking total time in cut 6.2 min without showing excessive flank wear or edge damage. The critical wear criteria are flank wear and plastic deformation in combination.

The insert according to the invention shows improvements in these respects.

Example 4

Inserts from A and B were tested in a turning operation.

Operation:	Continuous cutting of a housing
Work piece material:	Duplex stainless steel, SS2377
Cutting speed:	110 m/min

Feed rate:	0.3 mm/rev
Depth of cut:	1,35 mm
Insert style:	WNMG080412-MR

Results:	Tool life (min)
Insert A: (invention)	46
Insert B: (prior art)	24

Comment: This test shows a clear improvement compared to prior art. It is however difficult in this example to determine one single critical wear but it can be described as a combination of flank wear, flaking on rake and edge toughness.

Example 5

Inserts from A and B were tested in a turning operation.

Operation:	Intermittent cutting of a cast
Work piece material:	Austenitic stainless steel, AISI316
Cutting speed:	150-200 m/min
Feed rate:	0,1-0.15 mm/rev
Depth of cut:	2,0 mm
Insert style:	CNMG120412-PR

Results:	Tool life (items)
Insert A: (invention)	7
Insert B: (prior art)	2

Comment: This test shows improvement in toughness since the main wear criterion is edge toughness in this demanding application.

Example 6 (illustrative)

Inserts from C and D were tested in a turning operation.

Operation:	Facing of a bar
Work piece material:	Austenitic stainless steel, AISI304L
Cutting speed:	140 m/min

Feed rate:	0.36 mm/rev
Depth of cut:	maximum 4 mm
Insert style:	CNMG120408-MM

Results:	Wear pattern
Insert C: (reference)	Limited flaking on rake (Fig. 4)
Insert D: (reference)	Widespread flaking on rake (Fig. 5)

Comment: This example shows improved flaking resistance compared to the reference implying the importance of alumina layer thickness.

Example 7 (illustrative)

Inserts from C and E were tested in a turning operation.

Operation:	Combined facing and longitudinal turning
Work piece material:	Austenitic stainless steel, AISI316Ti
Cutting speed:	100-120 m/min
Feed rate:	0.3 mm/rev
Depth of cut:	2.0 mm
Insert style:	CNMG120408-MM

Results:	Total damaged edge outside cut
Insert C: (reference)	11,5 mm
Insert E: (prior art)	14,7 mm

Comment: Main wears are notch wear of the cutting depth and chipping outside the part of the edge in cut.

The example shows that the thin multilayer coating adds edge toughness compared to a coating according to prior art.

Example 8 (illustrative)

Inserts from C and E were tested in a turning operation.

Operation:	Combined facing and longitudinal turning
Work piece material:	Austenitic stainless steel, AISI304L

Cutting speed:	225 m/min
Feed rate:	0.3 mm/rev
Depth of cut:	2.0 mm
Insert style:	CNMG120408-MM

Results:	Tool life (min)
Insert C: (reference)	18
Insert E: (prior art)	13

Comment: Tool life criterion was maximum flank wear 0.3 mm of the cutting edge line. The wear develops irregularly due to local plastic deformation. This example shows that the thin multilayer coating add plastic deformation resistance compared to a coating according to prior art in this operation.

Considering example 7 this shows an improvement in these contradictory properties.

Example 9

Inserts from F and G were tested in a turning operation.

Operation:	Continuous cutting in a forged component
Work piece material:	Austenitic stainless steel, AISI316L
Cutting speed:	200 m/min
Feed rate:	0.3 mm/rev
Depth of cut:	2.0 mm
Insert style:	CNMG120416-MM

Results:	Tool life (pcs)
Insert F: (invention)	32
Insert G: (prior art)	19

Comment: The critical wear criteria are flank wear and plastic deformation in combination in this test. The insert according to the invention shows improvements in these respects.

In conclusion it can be stated that from the result of the examples given above it is evident that by combining a cemented carbide substrate with the given composition, the selection of the multilayered coating with specific thicknesses and the special

edge treatment a tool insert has been created with excellent cutting performance in that it combines much of what was believed to be contradictory properties as described in the introduction.

Claims

1. A cutting tool insert particularly for turning of steel comprising a cemented carbide body, a coating with a post treatment c h a r a c t e r i s e d in

- a first, innermost layer system of at least two layers of $TiC_xN_yO_z$ with $x+y+z\leq1$

- a second multilayer system consisting of totally 5-31, preferably 11-15, alternating layers of Al_2O_3 and $TiC_xN_yO_z$ ($x+y+z\leq1$), preferably κ-Al_2O_3 and TiN, the Al_2O_3-layers having an individual layer thickness of <0.5 µm, preferably 0.2-0.5 µm and the $TiC_xN_yO_z$-layers <0.2 µm, preferably 0.02-0.15 µm with a total thickness of the multilayer of 1.0-4.0 µm, preferably 1.5-3.5 µm and wherein the multilayer is exposed along the edge line and into the rake and flank face, such that $0.03<a<0.9$ mm and $0.02<b<0.2$ mm and $a>b$.

2. A cutting tool according to claim 1 c h a r a c t e r i s e d that the innermost layer system comprises

- a first layer $TiC_xN_yO_z$ with $x+y+z\leq1$, preferably $y>x$ and $z<0.2$, most preferably $y>0.8$ and $z=0$, with equiaxed grains with size <0.5 µm and a total thickness <1.5 µm but >0.1 µm, preferably 0.1-0.6 µm

- a second layer of $TiC_xN_yO_z$ with $x+y+z\leq1$, preferably with $z=0$, $x>0.3$ and $y>0.3$, most preferably $x>0.5$, with a thickness of 0.4-3.9 µm, preferably 1.5-3.0 µm with columnar grains.

3. A cutting tool according to claim 2 c h a r a c t e r i s e d in that the innermost layer system comprises

- a third layer of $TiC_xN_yO_z$ with $x+y+z\leq1$, preferably $y>x$ and $z<0.2$, most preferably $y>0.8$ and $z=0$, with equiaxed grains with size <0.5 µm and a total thickness <1.5 µm but >0.1 µm, preferably 0.2-0.8 µm.

4. A cutting tool according to any of the claims 1-3 c h a r a c t e r i s e d that the total thickness of the innermost layer system is 0.7-4.5 µm, preferably 1.2-4.0 µm.

5. A cutting tool according to any of the claims 1-4 c h a r a c t e r i s e d in an outermost layer system on top of the multilayer of one or more layers of TiC_xN_y ($x+y\leq1$) or combinations thereof, preferably three layers in sequence of TiN, TiC and TiN.

6. A cutting tool according to any of claims 1-5 c h a r a c t e r i s e d in a total thickness of the coating of 2.0-8.0 µm, preferably 4.0-7.0 µm.

7. A cutting tool according to any of claims 1-6 c h a r a c t e r i s e d in that the multilayer and partly the innermost $TiC_xN_yO_z$ layer system is exposed along the edge line.

8. A cutting tool according to any of claims 1-7 c h a r a c t e r i s e d in that the cemented carbide substrate has a composition of 7-10.5 wt% Co, preferably 8.0-9.5 wt% Co, 0.2-1.6 wt% cubic carbides, preferably 0.4-1.0 wt% cubic carbides of the metals Ta, Nb and Ti and possibly other carbides of the elements from group IVb, Vb or VIb of the periodic table and balance WC with an average grain size of 1.5-3.5 µm, preferably 1.9-2.1 µm.

9. A cutting tool according to any of claims 1-7 c h a r a c t e r i s e d in that the cemented carbide substrate has a cubic carbide depleted and binder phase enriched volume near the surface with a distance from the surface of 5-50 µm with a substrate composition comprising 7.0-10.5 wt% Co and 4.0-9.0 wt% cubic carbides of elements from group IVb, Vb or VIb of the periodic table preferably Nb, Ta and/or Ti and balance tungsten carbide, WC and an N-content in the range of 0.01-0.2 wt%.

ABSTRACT

The present invention relates to a cutting tool insert particularly for turning of steel comprising a cemented carbide body, a coating with a post treatment with

- a first, innermost layer system of one or several layers of $TiC_xN_yO_z$ with $x+y+z \leq 1$ with a total thickness of 0.7-4.5 µm

- a second multilayer system consisting of a totally 5-31 alternating Al_2O_3 and $TiC_xN_yO_z$ ($x+y+z \leq 1$), preferably κ-Al_2O_3 and TiN, the Al_2O_3-layers having an individual layer thickness of <0.5 µm and the $TiC_xN_yO_z$-layers <0.2 µm with a total thickness of the multilayer of 1.0-4.0 µm. The multilayer is exposed along the edge line and into the rake and flank face, at least 0.02 mm, from the edge line on the rake face, preferably the contact length of the chip at most 0.9 mm, and 0.02-0.20 mm on the flank face.

	A (invention)	B (prior art)	C (outside invention)	D (outside invention)	E (prior art)	F (invention)	G (prior art)
ubstrate							
o/Ta/Nb (wt%)	8.75/1.17/0.29	10.5/1.16/0.28	9.15/1.17/0.29	9.15/1.17/0.29	9.15/1.17/0.29	7.5/2.72/0.44	7.5/2.72/0.44
i/N (wt%)	-/-	-/-	-/-	-/-	-/-	1.83/0.09	1.83/0.09
oating							
iN (innermost layer)	0.5 µm	0.5 µm	0.5 µm	0.5 µm	0.5 µm	0.5 µm	0.5 µm
i(C,N)	2.2 µm	4.0 µm	2.2 µm	2.3 µm	2.2 µm	2.2 µm	7.5 µm
iN	0.5 µm	-	-	-	-	0.5 µm	-
l2O3/TiN)$_x$,Al2O3 or solid Al2O3	2.2 µm, x=6	1.0 µm solid Al2O3	1.8 µm, x=5	1.9 µm, x=3	1.5 µm solid Al2O3	2.2 µm, x=6	1.2 µm solid Al2O3
iN+TiC+TiN	0.5 µm	0.5 µm	0.5 µm	0.5 µm	0.5 µm	0.5 µm	0.5 µm
ost treatment	Acc to invention	Prior art	Prior art	Prior art	Prior art	Acc to invention	Prior art
esults							
. plastic deformation (tool life)	10 min	6 min					
. combined wear (tool life)	8.2 min	4.2 min					
. toughness and wear resistance (tool life)	18.6 min	12.4 min					
. toughness and adhesion (tool life)	46 min	24 min					
. toughness (no of items)	7 items	2 items					
. flaking			Limited	Widespread			
. edge toughness (damaged length)			11.5 mm		14.7 mm		
. plastic deformation (tool life)			18 min		13 min		
. flank wear and plastic deformation (no of items)						32 items	19 items

Table 1.

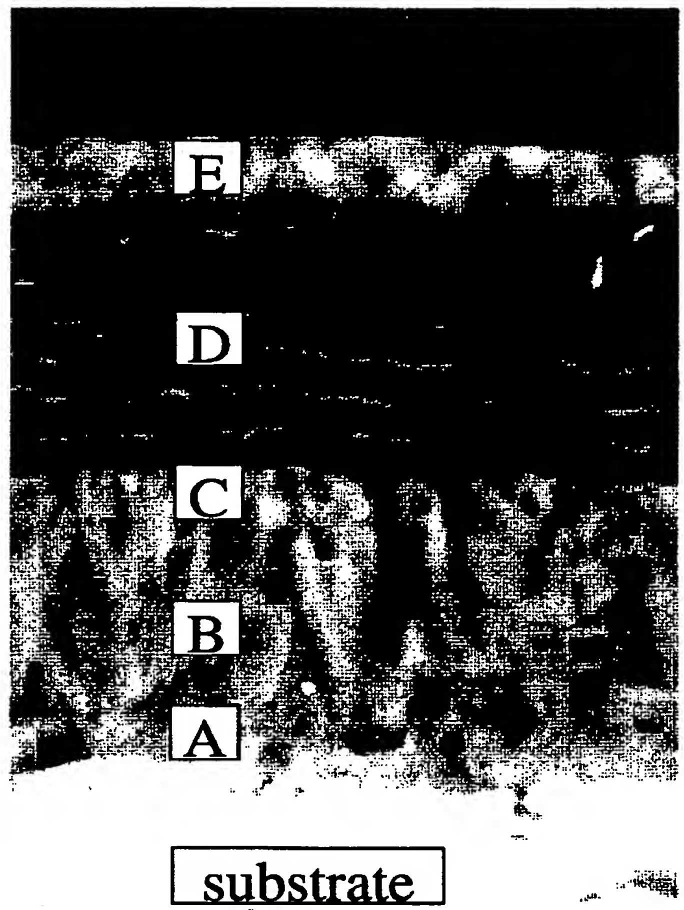

Fig 1.

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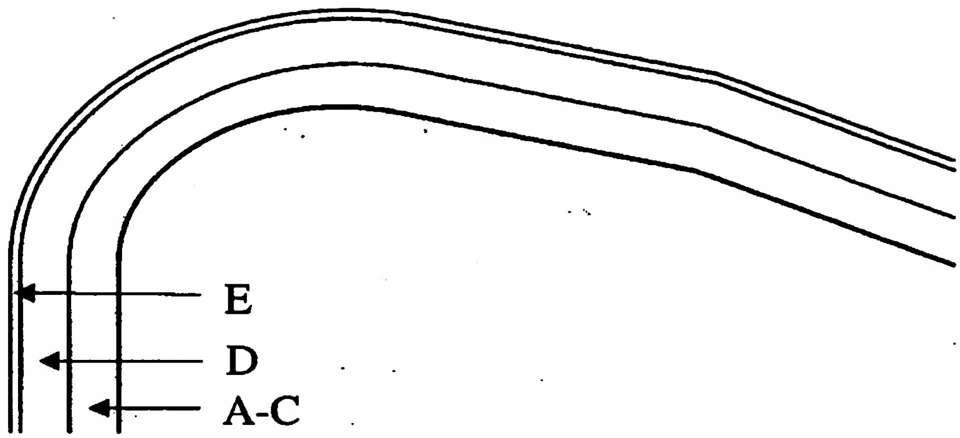

Fig 2.1

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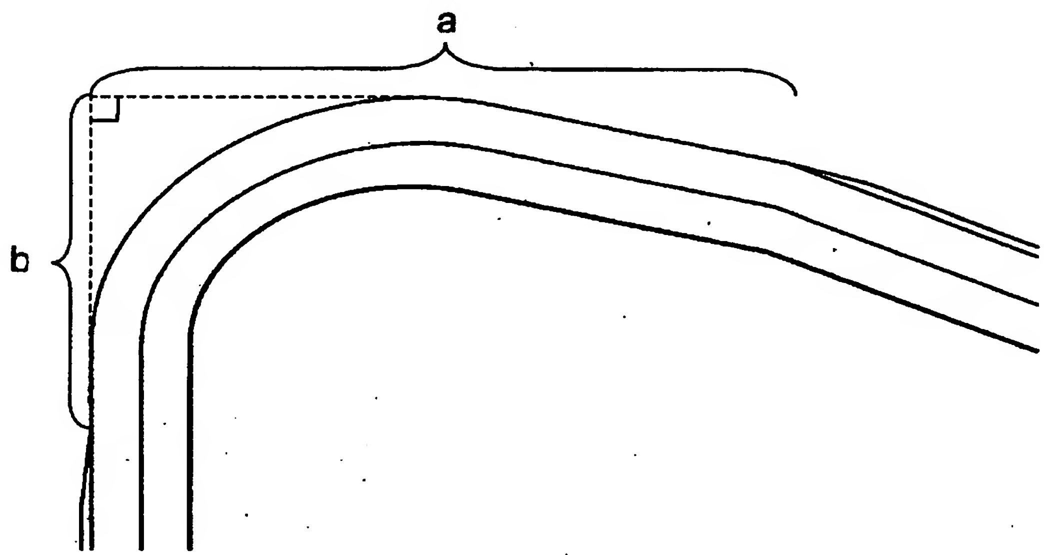

Fig 2.2

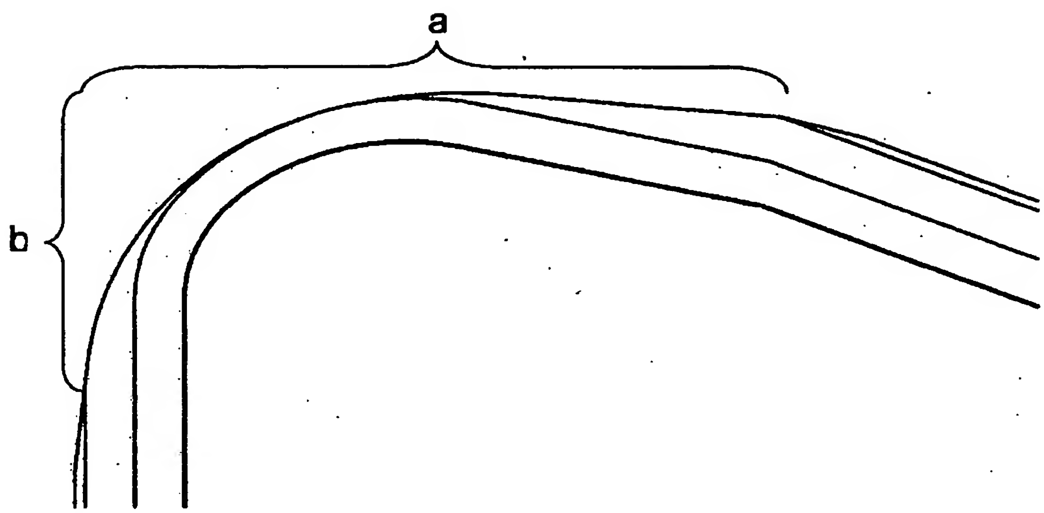

Fig 2.3

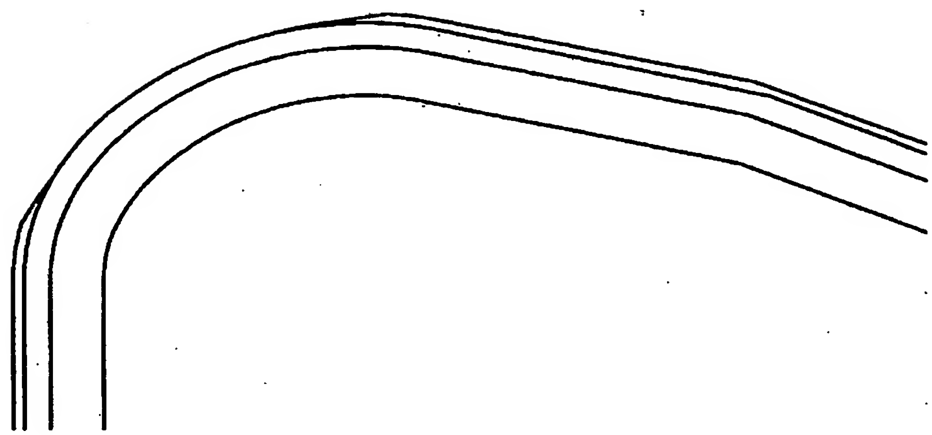

Fig 3

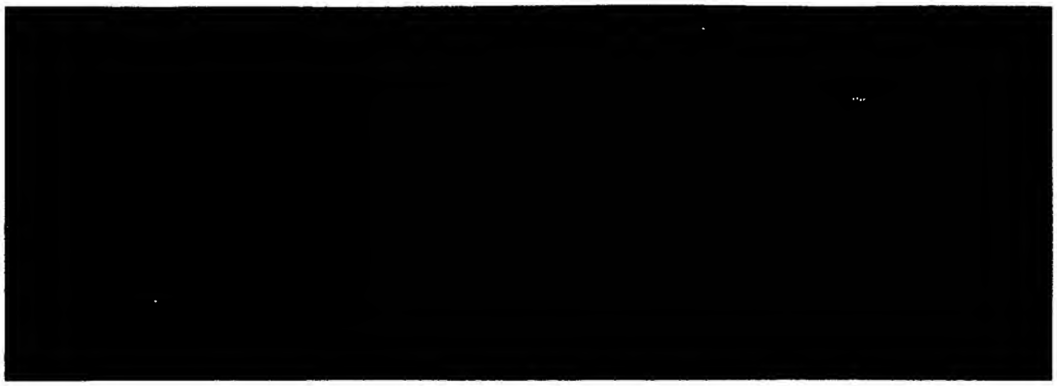

Fig 4

Fig 5